UNITED STATES MARINE CORPS
Logistics Operations School
Marine Corps Combat Service Support Schools
Training Command
PSC Box 20041
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AOM 6304

STUDENT OUTLINE

TUBING AND TUBE FITTINGS

LEARNING OBJECTIVES:

1. Terminal Learning Objectives:

a. Given a student handout entitled "Tubing and Tube Fittings," complete statements to identify the application of tubing in automotive vehicles, per information contained in the reference provided. (6.3.5)

b. Given a student handout entitled "Tubing and Tube Fittings," the required tools, supplies and equipment, connect tubing per information contained in the reference provided. (6.3.6)

2. Enabling Learning Objectives:

a. Given a student handout entitled "Tubing and Tube Fittings" and a list containing the names of four tube fittings and illustrations of those fittings, match each illustrated fitting with its correct name, per information contained in the reference provided. (6.3.5a)

b. Given a student handout entitled "Tubing and Tube Fittings" and illustrations of tube fittings, identify the point where the sealing occurs on each fitting, per information contained in the reference provided. (6.3.5b)

c. Given a student handout entitled "Tubing and Tube Fittings," the required tools, supplies and equipment, per information contained in the reference provided:

(1) cut the copper tubing smoothly at right angles to the center of the tubing, (6.3.6a)

(2) prepare the tubing for a fitting, (6.3.6b)

(3) flare the copper tubing to a tube fitting, and (6.3.6c)

(4) connect the tube fitting. (6.3.6d)

OUTLINE

1. INTRODUCTION TO TUBE FITTINGS

a. Frame #1. Tube Fittings (Title frame - no narrative)

b. Frame #2. Tubing and tube fittings are a common means of moving gases and liquids in modern equipment of all kinds. Applications vary from low pressure air controls to high pressure hydraulic systems.

c. Frame #3. Maintenance of most industrial machinery, construction and mining equipment, refrigeration and heating units, private, commercial and tactical automotive equipment, and many other devices involve tubing connections.

d. Frame #4. Whatever the application, to get the best performance from the fittings you use, you must be able to identify and use them correctly. In this program we will identify the standard types and see how they are used.

e. Frame #5. Tubing can be made from different materials, such as: copper, aluminum, steel, stainless steel, nylon and thermoplastic.

f. Frame #6. The material a tube is made from determines what substances it can safely convey, its flexibility, resistance to corrosion, and how much pressure, heat, and vibration it can handle.

g. Frame #7. Some metal tubing is seamless, some has welded seams, and some has double walls which are brazed together.

2. IDENTIFYING TUBE FITTINGS:

a. Frame #8. Tube fittings are also made from different materials, like brass, steel and synthetics. Each fitting is designed to be used with certain types of tubing.

b. Frame #9. There are two basic types of tube fittings...those that require a flared tube and those that don't.

c. Frame #10. Flare fittings seal by clamping the tube flare between internal seats.

d. Frame #11. The most common flared tube fittings used today are SAE 37 1/2 flared hydraulic fittings (also known as JIC fittings [Joint Industrial Conference]), the 45 1/2 SAE automotive and refrigeration fittings, and the SAE inverted flared fittings.

e. Frame #12. The 37 1/2 and 45 1/2 flared fitting bodies look very similar, but the seat angle is different.

f. Frame #13. 37 1/2 JIC flared fittings are most often made of steel. They are commonly used in hydraulics and other medium to high pressure applications. JIC stands for Joint Industrial Conference, which first set the standards for these fittings.

g. Frame #14. 37 1/2 JIC fittings are available as either two piece or three piece assemblies. The three piece assembly has a sleeve which helps to align and reinforce the flare for a better seat.

h. Frame #15. 45 1/2 flared fittings are usually made of brass and are used in a wide variety of applications to transfer fuels, oil, water and gases.

i. Frame #16. 45 1/2 flared nuts are available in different lengths. The longer nuts provide more tube support for applications where vibration occurs. The forged nut on the right is used for refrigeration application.

j. Frame #17. Inverted flared fittings are commonly used on automotive fuel, oil and brake lines. The seat angle is 45 1/2.

k. Frame #18. They have male threads on the nut, just the opposite of regular 37 1/2 and 45 1/2 flared tube fittings.

l. Frame #19. Compression tube fittings do not require a flared tube. They seal by compressing a sleeve or ferrule onto the tube.

m. Frame #20. Most compression fittings consist of three parts: a body, sleeve, and nut.

n. Frame #21. There are many types of compression fittings: tapered sleeve, spherical sleeve, nylon air brake fittings, threaded sleeve, flareless hydraulic fittings, and fittings for synthetic tubing.

o. Frame #22. The tapered sleeve fitting is used with copper, brass and aluminum tubing. It is designed for use in low and medium pressure systems where vibration is minimal.

p. Frame #23. The tapered sleeve fittings can also be used with synthetic tubing. An insert is pushed inside the tube for support.

q. Frame #24. The spherical sleeve fitting is a common air brake fitting. It is designed to be used with annealed copper tubing.

r. Frame #25. Flanged sleeve compression fittings are used with nylon air brake tubing and in other similar applications. Flanged sleeve bodies are much like spherical sleeve bodies except that the flanged sleeve body has a built-in tube support.

s. Frame #26. Fittings used for air brakes are marked with a Department of Transportation approval. When replacing air brake lines, be sure to use approved fittings.

t. Frame #27. Tapered, spherical and flanged sleeves are not interchangeable. It is important to avoid mixing the components of these different fittings.

u. Frame #28. The threaded sleeve compression fitting has only two parts. The sleeve is a part of the nut. It is used in low pressure applications.

v. Frame #29. Flareless hydraulic fittings are used with steel, aluminum, hard copper, and heavy wall tubing that is not flared.

w. Frame #30. The sleeve bites into the tube and is held there when the fitting is tightened.

x. Frame #31. There are a variety of fittings used for thermoplastic tubing. The simplest is the barbed push on fitting. These are easily pushed into the tube for low pressure applications.

y. Frame #32. Compression fittings are also used with synthetic tubing in low pressure systems. This type has a sleeve held captive in the nut.

3. THREAD IDENTIFICATION

a. Frame #33. Tube fitting threads are different than straight pipe or tapered pipe threads. Tube fitting threads are not designed to seal. They provide the clamping force necessary to squeeze the tube flare, compression ring, or sleeve tightly against its seat. This contact provides the seal.

b. Frame #34. Tapered pipe threads are designed not only to connect and disconnect the fitting, but also to seal tightly so that the gas or liquid passing through doesn't leak.

c. Frame #35. For hydraulic applications, National Pipe Thread Fuel (also called dry seal pipe threads) are often used. They are manufactured to closer tolerances than ordinary tapered pipe threads and are more resistant to leakage.

d. Frame #36. National Pipe Straight Mechanical threads do not seal on the threads. They have a 30° chamfer on the inside diameter which provides the seal.

e. Frame #37. SAE straight thread boss fittings have an "O" ring on the male fitting which squeezes into a chamfer at the top of the female thread.

f. Frame #38. Some straight thread boss fittings have a washer and locknut which allows accurate positioning of elbows and other fittings requiring directional alignment, while still maintaining a good seal.

g. Frame #39. British pipe thread standards include tapered threads which seal like National pipe threads. There are also British standard parallel threads which are similar to National straight pipe threads. While National and British pipe threads may look similar, they are not interchangeable. The main difference is the thread pitch or the distance between the threads.

h. Frame #40. Metric tube fittings are used with metric size tubing. They usually have either a 24 or 60 degree recessed chamfer. The 24° body can be used as a flareless fitting with a sleeve and nut. Both the 60 and 24 degree bodies seal with metric females which have matching internal seats.

4. CONNECTORS AND ADAPTERS

a. Frame #41. There are many different connectors available for each type of fitting. Here is a male connector with tube fittings on one end and male pipe threads on the other end. In place of the pipe threads you could have an SAE straight thread boss or a variety of male connectors.

b. Frame #42. Here is a female connector. It has tube fitting threads on one end and female pipe threads on the other. In place of female pipe threads, you could have a variety of female connectors.

c. Frame #43. A union has tube fitting threads on both ends.

d. Frame #44. Elbows come in either 45° or 90° angles. They can have tube fitting threads on only one end or they can be union elbows with tube fitting threads on both ends.

e. Frame #45. Tees can have tube fitting threads on all three sides. This is called a union Tee.

f. Frame #46. A run Tee has tube fitting threads 90° from each other. A branch Tee has tube fitting threads opposite each other.

5. MEASURING TUBING AND FITTINGS

a. Frame #47. Tube fitting sizes match the outside diameter of the tube they are used with. The easiest way to determine the size of a tube fitting is to measure the diameter of the opening in the nut where the tube enters. You can measure it as shown.

b. Frame #48. Or you can use a tube of a known size. The tube should slip in with very little clearance.

c. Frame #49. Tubing and fitting sizes are given in dash sizes. These indicate the diameter in sixteenths of an inch. -8 indicates 8/16ths or 1/2 inch. -6 is 6/16ths or 3/8ths inch. Dash sizes are found in part numbers used when ordering tubing and fittings.

d. Frame #50. If the fitting has pipe threads, then you'll have to measure both the tube fitting size and pipe thread size.

e. Frame #51. The actual outside diameter of pipe fittings is approximately 1/4 inch larger than their size designator. For example: a 1/8 inch NPT fitting will measure 3/8ths inch on the outside. A 1/4 inch fitting measures 1/2 inch on the outside and a 1/2 inch fitting will measure 3/4 inch.

f. Frame #52. The diameter of all tubing is measured in inches or millimeters across the outside of the tube.

g. Frame #53. The inside diameter depends upon the outside diameter and thickness of the material. A 1/2 inch tube with heavy walls will have a smaller inside diameter than a thin walled tube.

h. Frame #54. When selecting tubing you must be sure that the inside diameter is adequate to handle system flow and that the material and wall thickness is capable of withstanding system pressure. Tubing suppliers have the engineering data necessary to select the right tubing for the job.

i. Frame #55. Tubing comes in bulk rolls in specific lengths for special applications. Unroll bulk tubing as shown here so you will not kink or squash it. Hold the end down with one hand and unroll the coil with the other hand.

6. CUTTING TUBING

a. Frame #56. To cut metal tubing, use a tube cutter like this one. Lightly tighten the cutting wheel feed screw 1/4th of a turn, then make one complete revolution with the cutter around the tube. Alternately tighten and rotate the cutter until the tube is cut. If you tighten the feed too much, you'll flatten or distort the tube.

b. Frame #57. Cutters usually have a groove which allows clean cut of flared tubes with a minimum of material waste.

c. Frame #58. After cutting the tube to the desired length, ream both ends to remove the ridge caused by the cutter. Be careful not to allow dirt or reaming chips to fall into the tube. It may be necessary to flush or blow out the tube to remove contamination.

d. Frame #59. Most plastic rubber and neoprene tubing can be cut with shears or a knife. Cut squarely and don't allow dirt or pieces of cut material to enter the tube.

7. BENDING TUBING

a. Frame #60. Here are two commonly used devices for bending metal tubing. The spring type comes in several sizes, one for each size of tube. It is slid over the tube which is then bent by hand. The lever type makes more precise bends. Whichever bender you use it is important not to make the bend radius too small or you will weaken the tube and restrict the flow.

8. FLARING TUBING

a. Frame #61. If the tube is to be used with flared fittings, use a flaring tool like the one shown to form the flare in the ends of the tube.

b. Frame #62. First slide the appropriate nut onto the tube. You will not be able to get it on once the flare is made.

c. Frame #63. Insert the tube into the flaring clamp and tighten the wing nuts. Notice that the end of the tube extends slightly above the surface of the flaring tool. If the tube extends above this surface too far, the flare will be too big and will not fit into its seat. If the tube does not extend above the block far enough, the flare will be too small and may pull out or leak.

d. Frame #64. Now, move the other half of the tool into place and tighten the flaring cone snugly.

e. Frame #65. The flare should look like this when finished. This is a single flare.

f. Frame #66. For more strength in high pressure applications, a double flare is often recommended. To make a double flare, you will need a special anvil.

g. Frame #67. The anvil starts the flare by bending the tube inward. The double flare is finished with the regular flaring cone.

9. ASSEMBLING AND TIGHTENING FITTINGS

a. Frame #68. Proper assembly and tightening of fittings is essential if optimum performance is expected. Special tubing wrenches are available which will slip over the tube. These wrenches provide a firmer grip on the fittings than would an open end wrench.

b. Frame #69. When working with tubing and tube fittings, keep everything, including your tools and hands clean. Dirt will cause threads to bind. Both flared and compression joints can leak if they are dirty when connected.

c. Frame #70. Thread compounds and sealants should not be used on flared and compression fittings. The clamping force on the flare or compression sleeve does the sealing, not the threads.

d. Frame #71. You may use sealants on fittings that use tapered pipe threads. Apply it only to the male threads. Leave the first few threads free of sealant and do not use too much because it may enter the system and cause damage to components downstream.

e. Frame #72. Flare fittings are assembled by first sliding the nut onto the tube and then flaring the end of the tube.

f. Frame #73. Lubricate the threads and hand tighten the fitting.

g. Frame #74. The amount you must wrench tighten flared fittings varies depending on the material it is made from, the size, and the type of tubing used. Your local supplier has the manufacturer's recommendations for tightening the fittings you use. Unless a fitting is attached solidly to a bulkhead, it will be necessary to use two wrenches: one to hold the fitting body and one to turn the nut. Otherwise, you risk twisting and damaging the tube.

h. Frame #75. Compression fittings are assembled by sliding the nut and sleeve onto the tube, then inserting the tube all the way into the fitting body.

i. Frame #76. Lubricate the threads and assemble hand tight.

j. Frame #77. The amount you must tighten compression fittings beyond hand tight depends on the type of fittings and tubing. It also depends on the size.

k. Frame #78. If a compression fitting is too loose, it will leak. If too tight, the sleeve and tube will be damaged. Since there is no rule that applies to all compression fittings, the best policy is to check the manufacturer's recommendations for tightening the particular fitting you are using.

l. Frame #79. Learning to identify and use tube fittings correctly is important for anyone who works with them regularly. There are many special fittings in use today. We have covered only the most common ones. Again, if you have questions about tubing or fittings, your local supplier probably has the answers.

m. Frame #80. The End.

10. CUTTING, FLARING AND BENDING TUBING. a.

(1) When making a line from tubing the first step, after selecting the size and material of which the line is to be made, is to cut it to the length desired.

(2) In cutting tubing only a special tubing cutter should be used, as it is imperative that the tubing be cut smoothly and at right angles to the center line of the tubing to make a leak-proof joint.

(3) The cutting wheel of the tubing cutter is adjusted until it contacts the surface lightly.

(4) The complete tool is then swung completely around the tubing, after which the cutting wheel is again adjusted.

(5) The procedure is repeated until the cut is completed.

(6) After the tubing has been cut to the desired length, the ends should be reamed to remove any burrs from the tubing.

b. Flaring

(1) When making a flare, the tubing is placed in the flaring bar with the end protruding slightly above the face of the bar.

(2) Care must be taken that the tubing is clamped into the bar so pressure of the flaring cone will not force the tubing through the bar.

(3) Slip the yoke over the bar and start flaring by turning the screw handle clockwise.

(4) On tubes flared too short, the full clamping area of the fitting is not used and consequently the joint may leak or suffer early failure.

(5) Tubing flared too long will stick and jam on the threads of the fitting during assembly.

(6) Flares that are not straight usually result from the fact that the tubing was cut on an angle.

(7) Brazed steel tubing, such as is used for hydraulic brake lines, must be double flared.

(8) To make a double flare two operations are involved. In the first operation, the tubing is belled through the used of an adapter.

(9) In the second operation the adapter is removed and the flaring cone screwed down. This folds the tubing down on itself and forms an accurate 45 degree double flare without cracking or splitting the tubing.

c. Bending Tubing

(1) On smaller size tubing a simple outside bending spring is usually satisfactory.

(a) This bender is slipped over the outside of the tubing and prevents the tubing from kinking when it is bent.

(b) When using a spring-type bender, it must be remembered that the tubing must be bent somewhat further than required and then backed up to the desired angle. In that way the spring is loosened in the bender and can be easily removed.

(2) On larger sizes of tubing or when precise and uniform bends are required, a lever type bender should be used. This bender can be slipped on the tubing at the exact point the bend is desired, this is particularly

advantageous when the tubing has been partly connected, or is located in hard to reach places.

d. Plastic Tubing

(1) When using plastic tubing with a copper sleeve, flaring is not required.

(a) Place the tube fitting nut over the tubing along with the copper sleeve and attach the fitting nut to the brass connector.

(b) Use a flare nut wrench to tighten the nut securing the two components together.

(2) Verify the cuppling seal.

REFERENCE:

Industrial Training, Inc. Sound-Slide Program, "Tube Fittings"